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MONCRIEFF'S

METHOD OF MOUNTING ARTILLERY,

AS APPLIED TO

COAST DEFENCE.

From the Proceedings of the Royal Institution of Great Britain.

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WEEKLY EVENING MEETING,

Friday, May 7, 1869.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. President, in the Chair.

Captain Moncrieff,

On the Moncrieff System of Working Artillery as applied to Coast Defence.

Until the time of the Crimean war very little and very slow progress had been made in artillery. Cannon were manufactured on nearly the same models, and of the same materials that had been used for 300 years.

Before that time cast-iron was not in use, but the forged or bronze guns, although in some cases large, were not what is now considered powerful; and the penetration of their shot was not sufficient to pass through a parapet of earth that is now pierced even by light rifled artillery.

The conditions, therefore, under which artillery was worked, and the means provided for protection against its fire, remained much the same as they were in the time of Vauban.

Several events during the Crimean campaign confirmed an impression that has always been more or less entertained, that an increase in the power of individual guns produced greater results than could be obtained by a much greater weight of metal, distributed among a larger number of small pieces of artillery.

It is not too much to say, that the development of this art has, since 1855, changed the character of war both on land and water.

It has established completely the superiority of a few large pieces over a much greater weight of metal in smaller guns.

It has given artillery of all classes a range, a penetration, and an accuracy of *Fire*, which throw into the shade the greatest results that had been previously obtained.

It has also stimulated the advocates of cast-iron smooth bores to produce guns that might rival the rifled artillery; and yet it is by no means probable that the limit of power, either of large smooth-bores or rifled guns, has been arrived at.

When it became apparent that mighty results were to be obtained

from improved artillery, a great deal of engineering talent was directed to the subject. Comparatively new appliances, such as the steam-hammer, and new methods of working steel, were called to aid in the construction of the new and powerful guns. So much interest, indeed, was taken in the subject, and so much attention absorbed by it, that the conditions which these improvements in artillery themselves imported with them ran some danger of being neglected.

The power of artillery became so great, that the ordinary provisions for protection against its fire were rendered useless. Forts that were considered strong twenty years ago would crumble under the shock of modern projectiles, and in some cases would even be too weak to support the guns while they were fired.

That service which the new artillery affected most palpably was the Navy, and the Navy accordingly took the initiative in introducing means calculated to resist the penetration of the new and terrible projectiles. Every one is more or less conversant with the process that has been going on of covering ships' sides with iron, which has increased in thickness till it really looks as if the process at last would only be limited by a ship's power of flotation.

War-ships, however, not only protect their sides against shot, but they also carry the heaviest artillery on their decks. This fact could not be overlooked by those who had to construct coast defences, as well as other works against which modern heavy artillery might be used.

I shall not enter into details regarding the successive steps which were taken in England in this direction, as I understand Colonel Jervoise has already done so in this Institution. It is enough to state that great engineering skill has been exercised, and unwearied efforts have been made to meet the new conditions.

That skill and these efforts have, with the experiments at Shoeburyness, given us defensive iron structures which are marvels of strength and ingenuity. Unfortunately they are also marvels of costliness; and there is room to hope that their use will therefore be generally confined to such positions on *land* as can only be protected by such iron structures.

This hope is founded on another system, with which my name is connected, and which I am here to explain.

Before doing so I shall point out the dilemma which left military engineers no alternative, and which compelled them to give up in succession the use of earth, concrete, granite, &c., and at last to resort to the most expensive, but the strongest, material—*iron*.

There are two considerations always to be taken into account in providing the means of using artillery: the one is to place the gun so as to be most formidable to the enemy, and the other is to place it at the same time under as much cover as possible, so that *it* is not liable to be disabled, nor are the men serving it liable to be destroyed by hostile fire.

These two conditions interfere with one another; that is to say,

whatever has hitherto been gained in one direction has been lost in the other. Guns, *en barbette*, lack protection; guns in embrasures or in casemates sacrifice, on the other hand, free lateral range, and it is more difficult in their case to see the enemy, and therefore to lay the guns in action.

The difficulty that presented itself with the introduction of late improvements in artillery was simply that the increased precision and range, coupled with great improvements in the manufacture of large shells and also in small arms, rendered barbette batteries too exposed to be relied on. At the same time the tremendous penetration and precision of the new artillery rendered the ordinary parapet and embrasures useless.

What was to be done under these circumstances?

Protection from direct fire must be got at any price.

The first impulse would be, to thicken the parapet.

This could not, however, be done, as the necessary angle in the cheeks of the embrasures required for training the guns opens up a wider aperture, in direct proportion to the thickness of the parapet, making the *maximum* thickness in practice 30 feet.

But shot have been known to penetrate more than 30 feet into the earth; and the most important part of the parapet, *viz.* that near the guns, must always be thin and weak, whatever may be the thickness of the rest.

Shells, striking this part, would just meet sufficient resistance to burst them, and would make havoc among the men.

Next, granite masonry was thought of; but it proved in some respects worse than earth, and was found practically bad; there was no alternative but to go to iron. This conclusion was reluctantly arrived at, and reluctantly it was acted on.

The decisions of committees which investigated all the bearings of the question, the opinions of professional men, and the experiences of the American war, all coincided, and accordingly our important coast-works were designed to receive *iron* shields, casemates, and cupolas.

Vital positions in England, such as dockyards and arsenals, must be fortified. It would be false economy indeed to use any method of fortification that experience has proved to be insufficient. *No savings* could justify the erection of works that might prove at once the tomb of their defenders and perhaps of the nation's honour. Therefore the only proper decision was, to take that means to meet the difficulty which was at the time considered best and safest. Expense was properly a consideration very secondary in importance to efficiency.

I shall now endeavour to point out the difficulty of the task which lay before the engineer, even after the decision in favour of iron, from the extraordinary advances, already spoken of, in artillery. There is only one morsel of comfort left for those who have to provide for the requirements of defence, *viz.* that a form of artillery-fire of a very galling nature remains exactly as before, and indeed is not much better than it was in the time of Queen Elizabeth.

What is alluded to is vertical, or mortar fire. There is some consolation, too, in the reflection that the cause of this fire not being much improved is one to a great extent likely to be lasting. Rifled mortars would no doubt lessen deflection to right or left; but as long as gunpowder is affected in strength by the slightest atmospheric or other influence, and still more certainly as long as a slight error in elevation at long ranges will make a large error on the plane of fire, the comparative inaccuracy of vertical fire must continue.

To show how little can be done in this way compared with the admirable precision and accuracy of direct fire, I may state that 100 rounds were fired one day last season at Shoeburyness at 800 yards range with a 13-inch mortar at the row of experimental casemates which cover a good deal of ground. The mortar was laid with spirit-levels and all the appliances of the school of gunnery, and yet the 100 rounds were expended without a single hit.

If such is the case with a steady platform and under such exceptionally favourable circumstances, it can easily be seen how uncertain in its effects would practice be from mortar-boats, which move with every wave, if directed at an equally small object. During the eleven months' siege of Sevastopol the French had 242 mortars engaged, which were themselves exposed to vertical fire, and yet not one of these mortars was disabled.

It is indeed a strange contrast, that while direct fire is getting more powerful, more accurate, and more destructive every year, vertical fire remains much as it was, and can only be relied on to hit a large object, such as a fort, a town, or anything that covers a great deal of ground. Notwithstanding this, it would be a great mistake to despise it as a powerful and galling means of attack.

To return to the difficulties of meeting direct fire in coast defence.

It must be borne in mind that batteries intended to engage ships are obliged to meet an enemy who can move his position to that quarter where he is least exposed, who can continue in motion while he is conducting his attack, and who can seek out the most vulnerable face of the land-work to operate upon.

In constructing such batteries it is first of all necessary to make them of sufficient strength to resist the guns of ships which are the most powerful that can be made.

It is next required that these batteries should be constructed in such a manner that they can direct their fire with rapidity and precision in any direction in which the ships can take up their position.

And lastly, it is required that they should mount guns of sufficient weight and power to be formidable to the heaviest iron-clads.

In former times guns *en barbette* were preferred for this purpose, because they met the two first requirements alluded to; that is to say, that from not being confined by embrasures or ports, they were able freely to follow their floating enemy whatever position he might take up, naval fire at that time being neither so correct nor so formidable as

to make such batteries unserviceable. The case, however, is now completely changed; for not only have guns been improved, but ammunition also; and heavy shells are most destructive. Rear-Admiral Porter, of the United States Navy, in a report on coast defences, says, "Such guns, *standing so high up*, are just the objects that naval gunners would delight to explode their Shrapnell against, and from my experience in naval gunnery, the third shell would kill every man at the gun."

Von Scheliha, in his treatise on coast defences, says, "Guns mounted *en barbette* may always be silenced by an iron-clad."

This form of battery, therefore, is disposed of.

We shall now examine the difficulties connected with the other alternatives. Common masonry batteries have been condemned as worse than useless, as they would only make the ship's fire more destructive than if directed against guns *en barbette*.

Next comes the expensive alternative which has been adopted, *viz.* iron shields, casemates, and turrets. It is most interesting to examine how far this system of iron, the last alternative left, meets the three requirements of coast defence alluded to, and to see what very great difficulties had to be encountered in applying it.

The three requirements are thus recapitulated:—

1st. Strength of the battery to resist naval fire, and give sufficient protection to the men.

2nd. Power of fighting the guns with accuracy and effect, of following the enemy with ease as he moves, of being able to face him on any side from which he approaches.

3rd. Power of using the most formidable guns to advantage.

The first difficulty was to decide the matter of strength.

Now guns are becoming more and more weighty and powerful every day, and therefore the strength required to resist them is an unknown quantity.

An iron casemate of the present proposed strength costs, according to official returns, with all the battery adjuncts except the gun and carriage, about 5000*l.* or 6000*l.* for each gun. A 2-gun turret, about 25,000*l.* or 30,000*l.**

If guns of 50 tons are introduced in ships, as is proposed, these defences are at once quite inefficient, and it is not known how strong or how expensive should be the iron works to replace them. Such questions must be very embarrassing indeed to those who have to decide these matters. Besides protecting the gun and carriage from the enemy's shot, protection must also be given to the men. This is the most serious of all considerations in coast defence, for the following reasons:—

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* The price of a permanent Moncrieff battery, with magazines, &c., including the extra expense of carriages, is from 1100*l.* to 1500*l.* for each gun; an iron shield battery from 1800*l.* to 2000*l.* per gun; an iron casemate battery, from 5000*l.* to 6000*l.* per gun; a turret, from 12,500*l.* to 15,000*l.* per gun.

The best experience we have regarding naval attacks on land-works is derived from the late American war, in which a great many actions of that kind took place. It would be unwise to ignore this experience, because the increasing power of artillery only gives it more weight.

During the whole of that war very few guns were destroyed by the naval fire in earthen batteries.

At Fort Wagner only three guns were totally dismounted, although 2864 shot and shell were fired into it in forty-eight hours, and the bomb-proofs were hit 1200 times. Seventeen siege-mortars, several cohorns, and thirteen heavy pieces of artillery were incessantly employed.

At Fort Fisher the bombardment was opened at the rate of 115 shells per minute, and although the guns were mounted *en barbette*, only two of them were dismounted when the place fell.

At Fort Powell a tremendous bombardment from mortar and gun-boats (the most accurate firing being from 15-inch mortars) was maintained from 22nd of February till 2nd of March, and not a single gun was dismounted.

The success of the ships over the forts was gained by demolishing the works, and still oftener by making the service of the guns so dangerous that the men could not work them.

Rear-Admiral Porter, U. S. Navy, in his report on coast defence, states, "The new-fashioned casemates turned out to be no better than the guns *en barbette*. They were perfect slaughter-houses, and were piled up with dead and wounded. Every shell that went through the port-holes killed and wounded every man in the close casemate. This proved to me most satisfactorily that guns in casemates were no better protected from shells than those *en barbette*."

With such evidence as this before them, from men who were conversant with all the events of that great war, it was indeed a serious question to decide what was to be done. I myself cannot see how men in an iron casemate are as much exposed as in a barbette battery; but there is no doubt that if the port of the strongest casemate was as large as those referred to by Admiral Porter, it would be open in the same circumstances to the same dangers as the damage was done by entrance of shell through the port.

The protection a casemate would afford from vertical fire in such a case would be but a poor advantage if more correct and more deadly weapons than the mediæval mortar could still search out at times the exposed point of the casemate and kill every man inside.

The next requirement in a coast battery, *viz.* to be able to follow an enemy amidst clouds of smoke, and to lay the guns on him with precision and dispatch, formed a more embarrassing difficulty still.

On the one hand, the ports must be constructed for muzzle-pivoters to give protection. On the other hand, if they are made so small it is difficult to see through them, to fire correctly and quickly at different elevations, and on different sides on a moving enemy.

The battery is in the position of a knight who must either expose his vitals to his enemy's lance or put on armour that paralyzes his sword arm.

There is as much protection in the power of being able to strike as there is in being able to guard.

As naval actions are likely to be short and decisive, it must have appeared extremely doubtful whether it was worth purchasing increased safety at the expense of losing the attacking power.

The last of the three requirements in coast defence stated was the necessity of using the most powerful cannon.

This did not present the same difficulty as the other two, because the designers of our defences had been presented by my friend Captain Coles with the means of mounting the heaviest guns to fire in any required direction. When very large and valuable guns are used, it is not advisable to cramp their action and restrict it to a small area. The turret was therefore preferred to the casemate when lateral range was required; and though apparently very expensive it was in reality cheaper than casemates, because, although the mounting of the guns in this manner cost more, they were enabled to do much more work, and there was thus an economy both of guns and men.

Having thus far endeavoured to describe the extraordinary difficulties which the new improvements in artillery inevitably entailed on the engineers, I shall now direct your attention for a short time to the difficulties in which the same improvements involved the artillerymen themselves.

These difficulties, though not quite so important as the engineering ones, were very serious indeed, and have not yet been quite overcome. They consisted chiefly in the difficulty of making carriages and platforms strong enough for the new and powerful rifled guns. These pieces burnt enormous charges of powder, and hurled bolts as heavy as an old field-piece at 1000 feet a-second.

The recoil of such guns represents a violence of force the like of which man has never had to deal with before. Imagine 12, 18, or 25 tons of compact iron started in an instant into rapid motion with a violence that mocks the blow of a steam hammer.

This force has to be controlled and restrained. It is no wonder then that, when met directly and stopped by friction, as is now done in the ordinary system, the difficulties are enormous. The horizontal strain on the platforms, pivots, and racers, is so great that it has not yet been quite successfully met: constant changes and inventions are being made to render this force more harmless.

I hope I have now conveyed to your minds some idea of the embarrassment and difficulties which have fallen upon both the artillery and engineers by the rapid improvement of these formidable engines of war; and of the persistent and able struggle which both have maintained to meet directly the terrible forces with which they have to contend.

They have both succeeded to a wonderful extent, but their success

is blighted by that curse of the science they practise; the law that up to this time has existed—*viz.* that what was gained in protection was lost in efficiency, and the converse.

Happily I had the good fortune to conceive and develope an idea which abrogates this law. The very force the existence of which has been so great a difficulty in the artillery question has been compelled to perform a service that at once sweeps out of existence a great many of those other difficulties that embarrassed fortification.

When two evils co-exist, it is sometimes good policy to make them destroy each other.

I shall now refer shortly to the train of ideas that led me to think of solving the important problem in quite a different manner from that in which it had been attempted, which had led to the adoption of a most expensive class of works.

My solution gives a system capable of mounting the heaviest artillery, while it simplifies the vexed question of fortification. It gives protection without the expense of using iron, and free lateral range to the guns without exposure.

The system is indeed a simple one; it does not require either brute strength or heavy expenditure for its application; nor does it need mighty forges to weld iron walls to protect our guns and gunners; it only calls to our aid the simplest and most docile forces of nature.

Instead of trying to meet force by force, I make my guns bow to the inevitable conditions which science has imposed; and instead of wasting energy, money, and skill in attempts to raise a buttress against the new artillery, I employ the hitherto destructive force of recoil to lower the gun below the natural surface of the ground, where it can be loaded and worked in security and in comfort; and, at the same time, I have made that destructive force so much my servant that I compel it at my pleasure to raise the gun again into the fighting position whenever it is required.

In 1855, while watching the interesting operations before Sevastopol, and endeavouring, as well as I could, to understand the conditions under which the siege-artillery was used, I conceived the idea which is now realized. It was then that I saw the value of earth and the importance of simple expedients.

It was plain that the weak point of a battery was the embrasure, which formed a mark to fire at, an opening to admit the enemy's shot, and required constant repair even from the effects of its own gun, which in firing injured the revetments of the cheeks.

I also came to the conclusion in my own mind that a remedy for some of these defects could be devised. Afterwards I worked at various plans, of which sketches were made or models; but each design had defects which discovered themselves to me as my experience increased.

The real difficulty of the thing arose from the necessity of providing for the enormous strain of the recoil.

These early designs, which were sometimes excellent in other

respects, broke down at this difficulty, and although some of them no doubt would answer with small guns, they were not calculated to meet the tremendous recoil of large rifled pieces.

At last I hit on a simple principle that would meet this difficulty to advantage, the interposition of a moving fulcrum between the gun and platform. Then I knew that the problem could be solved; and feeling the great importance of the subject, I resolved to devote my efforts to working it out completely.

While directing my attention to this simple and then apparently obscure matter, I was, as you may imagine, neither an idle nor disinterested watcher of the progress of artillery. Every step in advance was riveting the certainty in my mind that the system would one day be required, and with this conviction I refused to allow either discouragement or delay to make me desist. I shall now endeavour to explain shortly the system which bears my name, as far as it relates to coast defence.

It consists of three parts:—

1st. The mechanical principle of the gun carriages.
2nd. The form internal and external of the batteries.
3rd. The selection of ground for placing the batteries, and the arrangement for working them to the greatest effect; or, in other words, the *tactics* of defence for positions where the system is employed.

The principle on which the carriage is constructed is the first and most important part of the new system, because on it depends the possibility of applying the other parts. This principle may be shortly stated as that of utilizing the force of the recoil in order to lower the whole gun below the level of the crest of the parapet so that it can be loaded out of sight and out of exposure, while retaining enough of the force above referred to to bring the gun up again into the firing or fighting position.

This principle belongs to all the carriages; but the forms of these carriages, as well as the method in which this principle is applied, vary in each case.

For instance, in siege-guns, where weight is an element of importance, the recoil is not met by counterpoise.

With heavy garrison guns, on the other hand, which when once mounted remain permanent in their positions, there is no objection to weight. In that case, therefore, the force of gravity is used to stop the recoil, because it is a force always the same, easily managed, and not likely to go wrong; and as these carriages are employed for the most powerful guns, it is a great advantage to have the most simple means of working them.

It has been already mentioned that the principal difficulty arose from the enormous and hitherto destructive force of the recoil of powerful guns; and here I shall point out the manner in which that difficulty is overcome.

That part of the carriage which is called the elevator may be spoken of and treated as a lever; this lever has the gun-carriage axle at the end of the power-arm, and the centre of gravity of the counter-weight at the end of the weight-arm, there being between them a moving fulcrum.

When the gun is in the firing position the fulcrum on which this lever rests is almost coincident with the centre of gravity of the counter-weight, and when the gun is fired the elevators roll on the platform, and consequently the fulcrum, or point of support, travels away from the end of the weight-arm towards the end of the power-arm, or in other words it passes from the counter-weight towards the gun.

Notice the important result of this arrangement.

When the gun is fired its axle passes backwards on the upper or flat part of a cycloid. It is free to recoil, and no strain is put upon any part of the structure, because the counter-weight commences its motion at a very low velocity. As the recoil goes on, however, the case changes completely, for the moving fulcrum travels towards the gun, making the weight-arm longer and longer every inch it travels. Thus the resistance to the recoil, least at first, goes on in an increasing progression as the gun descends, and at the end of the recoil it is seized by a self-acting pawl or clutch.

The recoil takes place without any jar, without any sudden strain, and its force is retained under the control of the detachment to bring up the gun to the firing position at any moment they may choose to release it. The recoil moreover, however violent at first, does not put injurious horizontal strain on the platform. In my experiments at Edinburgh with a 32-pounder, I found that so slight was the vibration on the platform caused by firing, that the common rails on which the elevators rolled in that experiment, and which were only secured in the slightest manner, did not move from their position, nor even when heavy charges or double shot were used, did sand and dust fall off their curved tops.

At a still earlier experiment made with a model of a 95-cwt. gun, the model was fired on the ice with excessive charges, and nevertheless remained stationary.

This valuable concomitant of the system cannot be appreciated fully without referring to the difficulties that have been experienced, and are now felt, in getting pivots, platforms, &c., on the ordinary system strong enough to mount the new artillery, where the recoil is stopped by friction applied directly by means of what are technically called *compressors* attached to the platform.

I shall not detain you by detailing these difficulties, but will only state that the first two 12-ton guns on ordinary carriages that were fired in casemates (which happened a few months ago) at Gilkicker Fort were both *hors de combat* the first shot. This alarming event showed that with all the experience of ancient and modern artillery (and the carriages referred to were the legitimate exponents of the results of that experience), there was still room to doubt whether the

problem of meeting recoil had been at that time completely solved by the existing system.

The accident referred to was serious, because it might occur in action, and in that event would disable the gun, *pro tempore*, as completely as if it had been dismounted by a shot.

Some credit may be claimed for the new system, on the ground that it provided a carriage for a heavy piece of artillery on an entirely new principle, in which not a single part was copied from anything that had been formerly used, dealing with new conditions and performing new functions that no other carriage had done, and yet this new carriage (the first complete one of its kind) has now fired *two hundred rounds*.

This practice has been carried out with only a few accidents which pointed to defects in the gearing, which were easily remedied.

By treating this violent force in the manner above described, a good deal of the strength that is required in other systems becomes unnecessary, and at the same time the recoil, however violent, can not only be met, but utilized.

Together with the carriages there are some improvements of minor importance, such as trunnion pointers, reflecting sights, graduated racers, and so on, which it would be out of place to discuss at present, but which contribute to the efficiency and completeness of the system, and are more or less required for carrying it out as a consistent whole for coast defence.

The second part of the system, *viz.* the profile of the batteries, is of the highest importance, because unless it is attended to great advantages are lost.

This, unfortunately, makes the system extremely difficult of adaptation to existing works. In order to get the full advantage of it no exterior slope of parapet should be exposed to the view of the enemy. This prevents him from being able to tell whether the fire be correct or wasted, and affords no means to him of correcting error.

The battery in fact is masked; so that at some distance, or in dull weather, a moving ship would have considerable difficulty in laying her guns on one battery, and still more difficulty if there were several batteries judiciously placed for the purpose of deceiving the eye.

It can easily be understood that the slightest error in elevation would either carry the shot harmlessly over the battery or else cause it to ricochet off the glacis or superior slope.

In fact when the gun is down the enemy has nothing to aim at but an undefined horizontal line.

In connection with this I should mention a very interesting fact, brought out by General Simmons at the last discussion of the Royal Engineers on a paper of mine.

He stated that on analyzing the range reports of the Armstrong and Whitworth competitive trials, which were very carefully conducted, he found that the mean horizontal and vertical errors were very different.

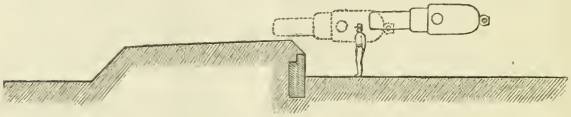
The horizontal error increased almost directly as the range, that is to say, at 400 yards it was four times as great as at 100 yards, but that the vertical error went on in a rapidly increasing progression, showing that it would be much more difficult to hit a low object than a high one of the same area.

This law has an important bearing on the subject, and should not be lost sight of in designing defensive works of any kind.

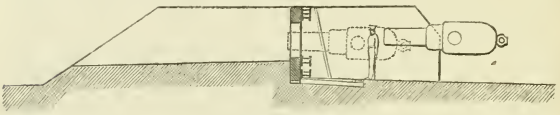
It will be observed that the interior slope of the parapet gives the most complete protection to the men, especially when the dome-form is adopted.

Sketch showing in Section Specimens of Five Methods of Mounting Heavy Coast Artillery.

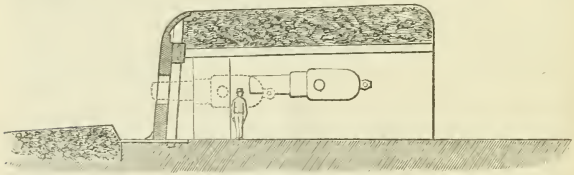
BARBETTE.



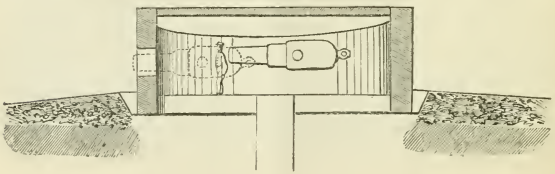
SHIELD.

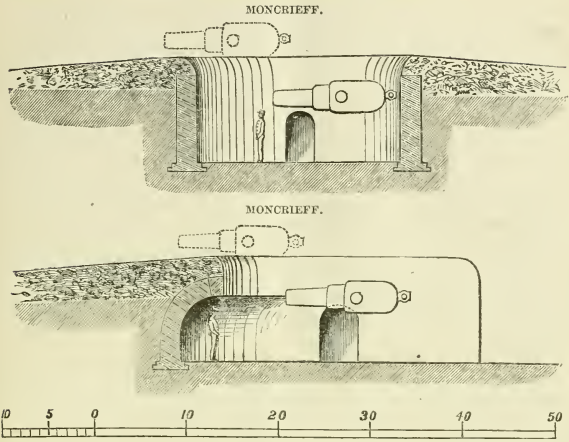


IRON CASEMATE.



IRON TURRET.





Up to the present time the new system has only been considered as an improvement, and its value has only been estimated as an adaptation to existing forts, and there are no proposals for applying it *per se*.

I am extremely anxious to impress on you and on my countrymen that its full value cannot be seen in this manner, and that it suffers injustice by being thus treated. I trust its proper use will be fully discovered before the inevitable lesson is dictated by war, and that it may be applied in works expressly designed for it, and not merely adapted to its use.

The third part of this system consists in its application to given positions, the disposition of the batteries, and methods of working them in concert with or in support of each other.

If I might be excused for using the paradox, the system for coast defence consists in the absence of any defined system; that is to say, instead of making large regular forts, and forcing surrounding circumstances into harmony with them, every accident of the ground in this case would be seized, where available, and small batteries, consisting of a few guns, or even one powerful gun, laid down so as not to take away the natural aspect of the position.

These batteries would be well retired from the channel, and placed so as to support each other in case of attack, and should, when circumstances permit, afford flank defence to each other, in conjunction with obstacles of any character that could be conveniently employed, and with strongholds for infantry and light artillery, commanding, if possible,

the sea-batteries, so as to make them untenable by an enemy, and so placed as to be in the best position for a reserve, ready to support any point attacked; the whole connected with good and sheltered roads.

In stopping the passage of a navigable river or channel, for instance, the guns, instead of being massed, would be scattered round the points where marine obstructions were placed.

These guns would be disposed in such a manner as to retain as much as possible for the defence the advantages of a free lateral range, converging fire, and different amounts of command. In other words, the method consists in placing in position the heaviest and most powerful artillery to the greatest advantage, making that the first consideration, and afterwards protecting the batteries, by separate and distinct arrangements easily devised by officers on the spot, against assault by any force that ships might land for that purpose.

When an object is to be attained, I prefer to grapple with the most difficult and important part of it first,—do that well,—and meet the other requirements afterwards, with as little loss of efficiency as possible.

The first object of coast defence is to meet and defeat the attack of powerful ships; the next is to protect the shore-batteries against landing parties.

It must not, however, be forgotten that there are positions of such importance that they might be attacked by an army on land. Such positions must either be defended by another army placed in a favourable position by such arrangements as those above referred to, or else by regular and complete earthworks thrown up in time of danger, which would enable a still smaller garrison to resist anything but regular approaches.

There are, however, few coast positions of such importance as to draw the attack of a whole army; and such positions, as a rule, are now provided with regular works of a very high order; whereas there are many positions exposed to a heavy naval attack, such as our large mercantile ports, &c. They are almost invariably centres of population, who require only fieldworks and good small arms (which are now more powerful than ever) to repel the most determined attacks of any numbers that war-ships could land.

I believe many of the *present* coast-works are defensible only against a *coup de main*.

Wherever land attack is of more importance than naval, the character and efficiency of sea-batteries must give precedence to those considerations which provide against assault. On the best provisions for meeting this I do not pretend to give an opinion. In such cases, the possibility of attack by both direct and vertical fire must be kept in view.

Where my system is employed for arming such works, one or two precautions would increase the power of resistance.

1st. The large guns for operating against ships, with traverses and *parados* to each, should be kept as far apart as space will admit.

2nd. Ample and thoroughly-complete bomb-proof cover for the whole garrison should, if possible, be supplied in the middle of the work, with arrangements for interior defence (not barracks, but places for emergency), thoroughly secure from vertical fire—good and healthy barracks for the men being made independent of the works, and by preference kept out of the way.

3rd. Howitzers and light artillery ought to be kept in reserve, in bomb-proofs constructed for the purpose, and (with the new system this can easily be done) also with the means of changing these to any required face.

The dispositions of defensive batteries such as those I have very imperfectly attempted to describe would not be complete without good arrangements for internal communications, not only by roads, but by telegraph, with a clearly laid down and simple method of working them; that is, not liable easily to go wrong, nor to lead to mistakes, and which would not require very high skill.

Such arrangements would increase the power of the defence, and indeed would be necessary with the detached system.

I have accordingly given them some attention, and designed a general plan of laying off the ranges and working the telegraphs, which will make it possible to supply simultaneous information.

The system I refer to (which has been submitted to the Director-General of Ordnance) would apply to any position, but its particular application would vary in each case.

It is extremely simple. One part of it depends on electrical instruments which I have invented for the purpose, and which, without either calculations or experience, give the range and positions of an indicated ship at every gun in the position.

Another part of it enables the officer directing the defence to deliver in one instant, by the touch of his finger, a converging volley from one or both sides of a channel on a vessel sailing past.

The possibility of delivering correct fire in this manner on a moving object, without aiming, and by an officer not even in the battery, was illustrated in one of my experiments with the 7-ton gun-carriage at Shoeburyness; and I trust I may be given some day a chance of showing to what perfection this system can be carried.

Methods of determining the distance of vessels from batteries are practised here and in some continental countries. My method is designed to be quicker, simpler, and therefore more effective. It is adapted to work in conjunction with the arrangements for submarine mines. That part of it which gives the required information for sighting the guns is of so simple a character, that the most uneducated gunner cannot make a mistake in its application.

There are many other features of the system besides those I have particularly referred to which I shall not now discuss; each requires different treatment.

Among these there are methods of mounting guns in ships, in

floating-batteries, Moncrieff-carriages for heavy guns of position, adapted for locomotion, for coast-defence, siege-carriages, &c.

I may remark in passing that some of these applications are considered by officers of eminence to be quite as important as the class of Moncrieff-carriages best known.

For instance, I take the liberty of quoting from a letter I received from Colonel Brialmont, the great Belgian engineer and military writer, in November, 1868. He says:—

"I am at present engaged in publishing a great work on fortifications. I shall naturally speak of your invention in it, and if agreeable to you I shall likewise mention your proposal with regard to *barbette* system in batteries of attack. I believe this idea is destined to have a great future. This last invention will perhaps bring you less renown than the one you have experimented on at Shoeburyness, but it will have a more general and easier application."

I am most anxious to impress the national importance of this question of coast defence in relation to the system of earthworks which are now possible.

The day has gone by when the general principles of any science need be considered a mystery, and I submit that any man of intelligence, without knowing all those details which are the particular business of officers trained to apply them, may nevertheless form valuable opinions on the general principles of coast defence, and may, with care and observation, be able to arrive at sound conclusions regarding them.

The security of a country like this does not depend so much on fortresses as on the efforts that can be made by a contented, brave, and patriotic people. If it is known by those who would invade us that we have not only brave hearts, skilled hands, and powerful guns, but a system of applying our resources that is capable of making any coast position formidable to war-ships, that knowledge will have its effect.

In war-time a good general disposes of his forces in that manner which will be most embarrassing and most formidable to the enemy. In time of peace we might arrange and prepare our coast defences on similar principles.

The improved artillery applied in earthworks made thoroughly efficient on the new system, together with the facilities which the existing network of railways slightly extended would supply, should be made to go some way in meeting the corresponding advantages, that have been conferred on the power of attack by steam navies and iron-clad war-ships.

If my labours have in any degree the effect of diverting the great resources of this country from a more expensive to a cheaper and more efficient system of coast defence both in the colonies and at home, and if thereby the security from outrage and disaster is increased, the consciousness of having helped to do so will itself be to me a reward for the delays, anxieties, and trouble that it has cost me to bring this matter forward.

[A. M.]